Rt to Lee and Tom for a decision 6/20/80

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June 3, 1980

RECEIVED
JUN 5 1980
DIVISION OF
OIL, GAS & MINING

Ronald W. Daniels
Coordinator of Mine & Land
Development
Division of Oil, Gas & Mining
1588 West North Temple
Salt Lake City, Utah 84116

RE: Rio Algom Lisbon Uranium Mine Reclamation

Dear Ron:

Enclosed is a photocopy of the Greene & Halpenny report on the 1971 flooding at the Rio Algom Mine at Moab, Utah. You will note from the report that the consultant's conclusion was that the water was definitely not from the Navajo or Kayenta formation, indicating that the breccia pipes do not traverse those acquifers.

If you have further questions, please feel free to contact me. We look forward to receiving your response to our proposal for reclamation of the mine shafts.

Very truly yours,

David R. Bird

DAVID R. BIRD
of and for
PARSONS, BEHLE & LATIMER

DRB/rla

cc: T. R. Sullivan

INVESTIGATION OF SOURCE OF INFLOW WATER TO VENTILATION SHAFT, RIO ALGOM, MOAB, UTAH PROJECT

By

D. K. Greene and L. C. Halpenny

Tucson, Arizona
June 18, 1971

Water Development Corporation
CONSULTANTS IN WATER RESOURCES

3938 Santa Barbara Avenue
Tucson Arizona 85711

Phone. 602-326-1133
Cable Wadevco. Tucson

June 18, 1971

Mr. Roy James, Project Manager
Rio Algom Corporation
Post Office Box 610
Moab, Utah 84532

Dear Mr. James:

Enclosed are five copies of our report related to the inflow water to the ventilation shaft.

Analysis of the inflow and pumpage data plus the quality-of-water data presently available indicates a distinct possibility that a major portion of the inflow water may have been derived from the overlying Wingate formation.

Of particular importance will be a detailed examination by Rio Algom personnel of the physical and geological conditions that exist in the vicinity of the inflow area once the drift face has progressed a sufficient distance.

Respectfully submitted,
WATER DEVELOPMENT CORPORATION

Leonard C. Halpenny

Leonard C. Halpenny
President

INVESTIGATION OF SOURCE OF INFLOW WATER TO VENTILATION SHAFT, RIO ALGOM, MOAB, UTAH PROJECT

By

D. K. Greene and L. C. Halpenny

CONCLUSIONS

1. The drawdown curve produced by pumping from the ventilation shaft shows that most of the inflow water was in storage trapped under substantial pressure.

2. There was an abrupt decrease in inflow rate at a depth of 2,050.5 feet below the shaft collar and another at a depth of 2,031.7 feet below the collar at which time the piezometric level, or pressure head, was at approximately the midpoint of the Wingate formation. It is considered that this represents the initial piezometric level of the inflow water and that the cause of the rise above this level was primarily from ground water entering the shaft directly from the overlying materials.

3. The initial inflow rate was in excess of 2,000 gpm (gallons per minute). The present fnflow rate, or throughput in the system, is on the order of 80 to 85 gpm.

4. The quality-of-water data for the inflow water show that the source of this water was definitely not from the Navajo or Kayenta formations.

5. The quality-of-water data of the inflow water, coupled with the initial piezometric level of this water indicate a definite likelihood that the

source of a major portion of the inflow water was from the overlying Wingate formation. This water may have moved downward along a structural feature or possibly through an old drill hole.

6. All of the data indicate relatively poor hydraulic communication and that the materials encountered so far do not have the ability to transmit large quantities of water on a sustained basis.

RECOMMENDATIONS

1. Continue keeping drill holes 50 feet ahead of the drift faces, as presently required by the Bureau of Mines, even if the Bureau relaxes these requirements.

2. Continue drilling an occasional long horizontal drill hole as was recently done in the haulage drift from the production shaft.

3. Use packers during drilling exploratory holes, if at all possible, so that if and when ground water is encountered it can be controlled and measurements of discharge versus pressure head decline can be taken.

4. Collect water samples for chemical analysis on a monthly basis for the next six months from the Wingate water ring in the ventilation shaft.

5. Make periodic observations of the quantity of water produced by the Wingate water ring in the ventilation shaft to see if there is any visible depletion in flow.

6. After the drift, where the inflow occurred, has advanced far enough to determine precisely just what conditions exist at this location (faulting, fracturing, intersection with old drill hole that has been cemented a substantial period of time after being drilled, etc) it is recommended that Rio Algom personnel make a detailed study of all geologic data from the drill holes and drill hole locations in the vicinity of proposed underground workings to determine the possibility of a similar situation existing at some other location. If such a location, or locations, can be pinpointed it should be checked out with a long horizontal drill hole as soon as the underground workings are within 200 to 300 feet of the potential trouble spot.

INTRODUCTION

On February 12, 1971, after completing 875 feet of the haulage drift from the ventilation shaft at Rio Algom's Moab, Utah, project a substantial flow of ground water was encountered issuing from the Cutler formation.

Water Development Corporation was subsequently retained by Rio Algom Corporation to review the pumping data and other data relevent to the inflow water, to make a preliminary report on the possible source of the water and to make recommendations on future procedures to follow to gain more information and prevent further water inflow occurrences.

Following a brief trip to Moab during the period March 31-April 2, additional data on pumpage and quality of water were requested by Water Development to be collected to assist in evaluating the problem.

These data have now been received and the purpose of this report is to present the results of the analysis of data available as of this date.

INFLOW AND PUMPAGE RATES

Initial Inflow Rate

Inflow rates are based on filling two drifts each 10 feet by 10 feet, having a combined length of approximately 2,000 feet, and on filling an 18-foot diameter shaft with a 40-foot sump at the bottom. The calculated volume of water required to fill the drifts and the lower part of the shaft to drift roof level is 1,600,000 gallons. The figure used for volume of the shaft above the roof of the drift is 1,900 gallons per foot of depth. Due to the conditions that existed during the initial inflow of ground water it was extremely difficult for Rio Algom personnel to estimate the exact time at which the drifts and sump were full. Using the estimated time at which the drifts and sump were full (12:00 pm February 12) would give an average inflow rate up to this time in excess of 4,000 gpm. From 12:00 pm February 12 to 11:00 am February 13 the water rose 276.2 feet in the shaft for an inflow rate of 795 gpm. As subsequent water-level measurements in the shaft showed inflow rates on the order of 1,100 to 1,300 gpm it is considered that the figure of 795 gpm is probably low, that the 4,000 gpm figure is high, and that the drifts and sump filled sometime after 12:00 pm February 12.

Using the measurement obtained at 11:00 am on February 13 as an anchor point gives an average inflow rate of approximately 2,100 gpm during the period of time it took to fill the drifts, sump, and lower 276.2 feet of the shaft. Water-level measurements taken in the shaft subsequent to this time indicate the following inflow rates as water continued to rise in the shaft:

Water Level Depth Below Collar of Shaft (ft) From	To	Increment of Rise in Shaft (ft)	Elapsed Time (min)	Inflow Rate (gpm)
2358.3	2316.5	41.8	60	1,325
2316.5	2277.7	38.8	60	1,230
2277.7	2242.1	35.6	60	1,125
2242.1	2208.6	33.5	60	1,060
2208.6	2170.9	37.7	60	1,195
2170.9	2135.3	35.6	60	1,125
2135.3	2106.0	29.3	60	930
2106.0	2078.8	27.2	60	860
2078.8	2050.5	28.3	60	895
2050.5	2039.0	11.5	60	365
2039.0	2031.7	7.3	60	230

Water Level Depth Below Collar of Shaft (ft) From	To	Increment of Rise in Shaft (ft)	Elapsed Time (min)	Inflow Rate (gpm)
2031.7	2030.7	1.0	60	31.7
2030.7	2030.2	0.5	60	15.8
2030.2	2029.5	0.7	585	2.3
2029.5	2029.3	0.2	180	2.1
2029.3	2023.3	6.0	1,185	9.6
2023.3	2016.3	7.0	1,440	9.2
2016.3	2013.3	3.0	1,440	4.0
2013.3	2009.3	4.0	1,440	5.3
2009.3	2006.3	3.0	1,440	4.0
2006.3	2005.3	1.0	840	2.3

The above water levels are plotted on Plate 1 along with the pertinent formation contact in terms of depth below shaft collar. The data show that there was an abrupt decrease of inflow rate at a depth of 2,050.5 feet and another abrupt decrease at a depth of 2,031.7 feet. The piezometric surface at this time was at approximately the midpoint of the Wingate formation. Considering that the Navajo-Kayenta sequence yields about 50 gpm and that all power was shut off during the night of February 12-13, the figures tabulated above should be reduced by about 50 gpm to indicate the rate of inflow from the break-in at the ends of the drifts. It is apparent, therefore, that inflow from the break-in became relatively ineffective when water in the shaft had risen to the 2,032-foot depth.

Subsequent Inflow and Pumping Rates

During the interval between February 19 and February 24 approximately 800 buckets, at 700 gallons of water per bucket, were removed from the shaft, following which the water was left undisturbed until March 3 when the No. 1 pump was installed. As of March 3 the water surface was in the Kayenta formation 1,729 feet below the shaft collar. Inflow rate from February 19 to March 3, giving consideration to the volume of water removed by bailing, was approximately 62 gpm.

The first attempt to operate the No. 1 pump was unsucessful and during the period March 3-7 while the pump was being repaired and reinstalled the water level rose from 1,720 feet below the shaft collar to 1,573 feet below the shaft collar in the lower part of the Navajo formation. Inflow rate during this period of time amounted to about 51 gpm.

The No. 1 pump was reinstalled and operated from March 7 thru March

12 at an average weighted discharge of 426 gpm. The water level dropped rapidly until March 10 at which time the piezometric surface was below the 2,000 foot depth and very close to the same elevation where the abrupt decrease in initial inflow occurred.

The No. 1 pump was shut off on March 12 while installing pumps Nos. 2 and 3. On March 14 all three pumps were placed in operation at an initial combined discharge rate of 1,300 gpm. The No. 1 pump failed on March 22 and pumps Nos. 2 and 3 were shut off while pulling pump No. 1 and again while reinstalling pump No. 1. Prior to shutoff the depth to pumping water level was about 2,315 feet. Recovery data during these two brief shutoffs indicate an inflow rate on the order of 260 to 290 gpm of which about 50 gpm was being contributed to the shaft by the Navajo and Wingate formations. Thus, actual inflow at this depth from the lower source of water was 210 to 240 gpm at this time compared to an initial inflow rate at this elevation in excess of 1,100 gpm.

The three pumps were again placed in operation on March 26. Drawdown was extremely rapid and by March 29 the shaft had been dewatered to a depth of about 2,565 feet. Pumps Nos. 1 and 3 were then shut off and pump No. 2 was operated intermittently to maintain the water level as low as possible with the existing pump arrangement.

Average pumping rates for March 30 and 31 and April 1 were 194, 181, and 174 gpm respectively. Assuming that the Navajo and Wingate formations further up the shaft were contributing 50 gpm, actual inflow rates from the lower source of water were 144, 131, and 124 gpm for these three days.

During the period April 1 thru April 11 the pumps were operated intermittently. The water level varied from a depth of 2,502 feet to about 2,581 feet. Total volume of water removed during this period of time was 2,290,000 gallons for an average pumping rate of approximately 160 gpm.

On April 11 the first Flygt pump was placed in operation and on April 17 the second Flygt pump was placed in operation. As of April 18 the water level was at the floor of the drift at a depth of 2,648 feet. As of May 19 the drifts were still being drained and during the period May 16 thru May 19 a total of 600,000 gallons were removed for an average pumping rate of about 140 gpm.

In summary the data from the inflow rates, water levels, and pumpage rates clearly show that the major portion of water which entered the drifts and shaft was ground water stored and trapped under substantial pressure. The through-put of ground water in the system is not precisely known but appears to be less than 100 gpm. Subsequent information received via phone from Mr. Sullivan, resident engineer, is that the discharge measured at the face where the inflow occurred is on the order of 80 to 85 gpm.

It is considered that the piezometric level, or pressure head, on the inflow water was equivalent to a depth of slightly over 2,000 feet below the shaft collar and that the cause of the rise above this depth was principally from water entering the shaft from the Navajo and Wingate formations.

QUALITY OF WATER

Ventilation Shaft

All of the available quality-of-water data from the ventilation shaft were reviewed and selected samples are included in Table No. 1. Sample No. 1 is one of the group of five samples which were submitted to Western Engineers, Inc. for an investigation related to physical or chemical reactions between the concrete shaft lining and water encountered within the shaft. The samples were collected from depths of 1,420 to 1,620 feet in the Navajo formation. The samples were almost identical in chemical characteristics and for this reason only one of the five samples is included in Table No. 1.

Sample No. 2 was collected from the ventilation shaft pump discharge when the shaft depth was approximately 1,790 feet in the Kayenta formation and probably represents a mixture of Navajo and Kayenta water.

Numerous samples of the inflow water were collected. Partial analyses were made on some of the samples and complete analyses were made on the remainder. Sample No. 3 is included on Table 1 as being representative of the chemical character of the inflow water.

Sample No. 4 was collected from the Navajo formation and Sample No. 5 from the Wingate formation in the vent shaft on April 16, subsequent to pumping out the inflow water. Additional samples were collected from these two sources on May 14. The repeat sample for the Navajo water was similar to the first sample collected. The repeat sample for the Wingate formation showed a substantially higher mineral content and is included on Table 1 as Sample No. 6.

The water samples from the Navajo formation (Nos. 1 and 4) are predominantly sodium on the cation side and bicarbonate and chloride on the anion side. Sample No. 2 (Navajo-Kayenta mixture) is similar in type to the Navajo, but more highly mineralized.

The chemical character of the inflow water differs considerably from the the Navajo and Navajo-Kayenta water. (The principal cation is still sodium, but the concentration is about three times that of the Navajo water and approximately 50 percent greater than the Navajo-Kayenta mixture.) The principal anion is still chloride, but again the concentration is substantially greater, with the range of increase being similar to that of sodium. Another significant difference between ithe inflow water and the Navajo and Navajo-Kayenta water is the

TABLE 1

QUALITY OF WATER DATA, VENTILATION SHAFT

LOWER H_2O RING

Sample No.	1	2	3	4	5	6
Source of Water	Navajo	Navajo-Kayenta	Inflow	Navajo	Wingate	Wingate
	DURING SINKING				From Shaft AFTER PUMPING	
Date	2-70	4-17-70	4-16-71	4-16-71	4-16-71	5-14-7[illegible]
Specific conductance, (micromhos at 25° C)	-----	------	4,810	2,290	3,380	6,400
pH	8.0	9.3	7.5	7.8	8.1	8.2
Calcium, ppm	12.2	8.0	28	20	12	36.0
Magnesium, ppm ?	20.6	8.2	17	15.8	4.9	20.4
Sodium + Potassium, ppm	392	815	1,230	557	868	1,640
Carbonate, ppm	7.2	95	6	6	27	9
Bicarbonate, ppm	342	175	415	403	422	? 420
Sulfate, ppm	22	17	375	62	475	500
Chloride, ppm	465	1,056	1,550	690	760	1,876
Fluoride, ppm	----	--------	1.3	1.6	1.4	1.2
Total salts, ppm	1,261.0	2,174.2	3,622.3	1,755.4	2,570.3	4,502.6

Unknown ?

SO_4 high sulfate content of the inflow water.

Sample No. 5 from the Wingate formation has less sodium and chloride than the inflow water, but has a higher sulfate content. Sample No. 6 from the Wingate formation is the most saline water encountered from sources in the vent shaft and shows a marked increase in sodium and chloride compared to the previous Wingate sample. This may possibly be due to the fact that the drawdown or dewatering cone of depression in the Wingate formation has intersected a pocket of stagnant more highly mineralized water. It would be desirable to collect water samples for analyses from the Wingate water ring on a monthly basis for the next six months.

In summary, the quality-of-water data from the vent shaft indicate the following:

1. The source of inflow water is definitely not from the Navajo and Kayenta formations;

2. The salinity of the inflow water is relatively high indicating semi-stagnant conditions and very poor aquifer characteristics insofar as the ability to transmit ground water is concerned;

3. A major portion of the volume of inflow water may have been Wingate water which gradually and slowly over a long period of time seeped downward, possibly along a structural feature, filling fractures or pore spaces in the lower formations or it may have moved downward through an old drill hole. Subsequent information received via phone from Mr. Sullivan, following observation of the face where the inflow occurred, is that the rock at this location is gray colored in contrast to the normal reddish color of the Cutler formation. The discoloration could be the result of alteration along a structural feature.

Production Shaft

Table 2 includes quality-of-water data for samples collected from the production shaft. Sample Nos. 1 and 2 were collected from the Navajo formation during shaft sinking at depths of 1,330 and 1,392 feet respectively. The water is similar in character to the Navajo water from the vent shaft and has a relatively low sulfate content.

Sample No. 3 was collected from the upper water ring which is 1,945 feet below the shaft collar in the Wingate formation and would represent a

TABLE 2

QUALITY OF WATER DATA, PRODUCTION SHAFT

Sample No.	1	2	3	4	5
Source of Water	Navajo	Navajo	Navajo-Kayenta-Wingate	Wingate	Cutler
Date	4-1-70	4-17-70	4-23-71	4-23-71	5-19-71
Specific conductance, (micromhos at 25° C)	------	-----	2,180	2,500	9,800
pH	8.1	9.5	8.5	8.4	8.3
Calcium, ppm	9.4	7.5	9.6	14.4	80
Magnesium, ppm	5.6	7.2	3.9	5.3	30.4
Sodium + Potassium, ppm	199.4	539	500	550	3,210
Carbonate, ppm	11.3	103	18	9	9
Bicarbonate, ppm	259	194	347	295	370
Sulfate, ppm	110	21	375	437	6
Chloride, ppm	118	620	423	446	4,998
Fluoride, ppm	------	------	0.6	0.6	1.4
Total salts, ppm	712.7	1,491.7	1,677.1	1,757.3	8,704.8

mixture of Navajo, Kayenta, and Wingate ground water. The high sulfate content of this sample compared to that of samples Nos. 1 and 2 would indicate a considerable portion of Wingate water in the sample.

Sample No. 4 was collected from the lower water ring which is set 2,081 feet below the collar near the Wingate-Chinle contact. The water is similar in character to the Wingate water from the vent shaft but less highly mineralized. There may possibly be a dilution effect from the water higher up in the shaft.

Sample No. 5 was collected from a horizontal test hole drilled in the haulage drift from the production shaft. The hole was drilled in the Cutler formation a total distance of 687 feet. At a distance of 375 feet a pocket of water under a pressure of approximately 185 psi (pounds per square inch) was encountered. The pressure was determined to be a result of methane gas. Initial water flow from the hole was approximately 10 gpm and it has since fallen off to about one gpm. Rock salt was used in drilling the hole and while the hole was allowed to drain before sampling it is quite possible that a portion of the high sodium-chloride content is due to contamination from the salt. Of particular,interest, however, is the very low sulfate content. It is considered that this is a pocket of connate water entrapped in the Cutler formation and that there is no hydraulic communication with the overlying formations, nor within the Cutler formation at this location.

The chemical character of this water also lends support to the probability that a major portion of the inflow water near the vent shaft was from the Wingate formation.